Claims:

1. A system for circulating blood in a patient comprising:

a cannula enclosing first and second flow paths, the cannula adapted in length and size to extend through an incision into a heart chamber or a blood vessel and adapted to provide blood intake at a first location in a heart chamber or a blood vessel and provide blood output at a second location in a heart chamber or a blood vessel;

a pump communicating with the first and second flow paths and operating to intake blood through the first flow path at the first location and to output blood through the second flow path at the second location; wherein

the pump and cannula, including the first flow path and the second flow path, having a combined priming volume external of the heart and blood vessel of not greater than about 1000 ml.

2. A system according to claim 1 wherein the priming volume is not greater than about 30 ml.

3. A system according to claim 1 wherein the priming volume is not greater than about 10 ml.

4. A system according to claim 1 wherein the length of the cannula is adapted to extend through the tricuspid valve, through the pulmonary valve, and into the pulmonary artery.

5. A system according to claim 1 wherein the length of the cannula is adapted to extend through the bicuspid valve, through the aortic valve, and into the aorta.

6. A system according to claim 1 wherein the first and second flow paths comprise concentric lumens within the cannula adapted for insertion through a wall of the heart.

7. A system according to claim 1 wherein the first and second flow paths are linear and adapted for insertion at the first end into a first heart chamber or blood vessel and at the second end into a second heart chamber or blood vessel.

8. A system according to claim 6 wherein the pump comprises a reverse flow pump.

9. A system according to claim 7 wherein the pump comprises a reverse flow pump.

10. A system according to claim 7 wherein the pump is coupled to the first and second flow paths of the cannula external of the heart.

11. A system according to claim 1 wherein the length of the cannula is adapted to extend through an incision in the vena cava or the right atrium and into the pulmonary artery, and the pump is adapted to convey blood from the vena cava or right atrium through the cannula into the pulmonary artery.

12. A system according to claim 1 wherein the length of the cannula is adapted to extend through an incision in the pulmonary vein and into the aorta, and the pump is adapted to convey blood from the pulmonary vein through the cannula into the aorta.

13. A system according to claim 11 further comprising:

a second cannula adapted to extend through an incision in the pulmonary vein or the left atrium and into the aorta, and

a second pump adapted to convey blood from the pulmonary vein or left atrium through the second cannula into the aorta.

14. A system according to claim 1 further comprising a controller coupled to the pump for controlling the pump speed.

15. A system according to claim 13 further comprising a controller for the first pump and the second pump for controlling the speed of each pump separately.

16. A system according to claim 14 wherein the controller is adapted to control the pump in response to blood pressure, blood oxygen level, blood carbon dioxide level or blood flow volume.

17. A system according to claim 15 wherein a controller is adapted to control the first pump in response to pulmonic pressure and a controller is adapted to control the second pump in response to aortic pressure.

18. A system according to claim 1 further comprising a cradle adapted for supporting the heart while displaced from its normal position and while the surgery is performed thereon.

19. A system for preventing collapse of the right atrium, right ventricle or pulmonary artery and maintaining blood flow there through during beating heart bypass surgery comprising:

a pump and cannula system wherein the cannula is adapted for insertion through the tricuspid valve, through the pulmonary valve and a sufficient length into the pulmonary artery to prevent collapse of the right atrium, right ventricle or pulmonary artery and to maintain partial blood flow there through while the beating

heart is lifted or displaced during surgery and wherein the pump and cannula are adapted for intake of blood upstream of the pulmonary valve and output of blood into the pulmonary artery while the beating heart is displaced during surgery; and

a controller for the pump adapted to control the pump in response to venous or pulmonic blood pressure, oxygen level, CO_2 level or flow volume.

20. A system according to claim 19 wherein the pump has a priming volume less than about 1000 ml.

21. A system according to claim 19 wherein the pump comprises a reverse flow pump having an adjacent motor and being adapted for operation adjacent to the heart during surgery.

22. A system according to claim 19 wherein the cannula comprises concentric conduits of different lengths and connected to the pump to provide inflow of blood to the pump through the outside conduit and outflow through the inside conduit.

23. A system for preventing collapse of the right atrium, right ventricle or pulmonary artery and maintaining blood flow across the pulmonary valve during beating heart surgery comprising:

a cannula adapted for insertion through the tricuspid valve, through the pulmonary valve and a sufficient length into the pulmonary artery to prevent collapse of the right atrium, right ventricle or pulmonary artery while the beating heart is lifted or displaced during surgery; and

a pump system adapted for removing blood from the vena cava or the right atrium and transporting the blood external of the heart into the pulmonary artery.

24. A method for performing beating heart surgery which comprises:

inserting the cannula portion of a pump and cannula system through the tricuspid valve, through the pulmonary valve and a sufficient length into the pulmonary artery to prevent collapse of the right atrium, right ventricle or pulmonary artery when the heart is stressed, lifted or displaced during surgery; and

pumping blood from upstream of the pulmonary valve into the pulmonary artery to augment or replace the flow of blood through the pulmonary valve produced by the beating heart.

25. A method for performing beating heart surgery which comprises:

inserting a cannula through the tricuspid valve through the pulmonary valve and a sufficient length into the pulmonary artery to prevent collapse of the right atrium, right ventricle or pulmonary artery when the heart is lifted or displaced during surgery;

connecting a pump intake tube through an incision in the wall of the right atrium to remove blood from the right atrium;

connecting the pump outflow tube into the pulmonary artery through an incision in the wall of the pulmonary artery; and

pumping blood from the right atrium through the pump into the pulmonary artery.

26. A method for sustaining sufficient blood flow in the patient during heart surgery which comprises:

inserting the cannula portion of a pump and cannula system through the interior of one side of the heart to extend the cannula into the artery or aorta; and

adjusting the pump output during the surgery to provide sufficient blood flow in the patient during the surgery.

27. A method according to claim 26 wherein the blood flow is pulmonary blood flow to the lungs of the patient.

28. A method according to claim 26 wherein the blood flow is circulatory aortic blood flow to the body of the patient.

29. A method according to claim 26 comprising:

inserting the cannula portion of a pump and cannula system through the interior of each side of the heart to extend one cannula into the pulmonary artery and the other cannula into the aorta; and

adjusting each pump output during the surgery to provide sufficient pulmonary blood flow and sufficient aortic circulatory blood flow in the patient during the surgery.

30. A method for performing beating heart surgery which comprises:

inserting in one side of the heart a cannula or stent adapted to protect the blood flow path through the heart when the stented portion of the heart is collapsed or kinked; and

performing beating heart bypass surgery while the cannula or stent is in place in the heart.

31. A method according to claim 30 wherein the cannula or stent is placed in the right side of the heart.

32. A method according to claim 31 wherein a second cannula or stent is placed in the left side of the heart.

33. A method of maintaining blood flow through the right side of the heart during beating heart surgery which comprises:

inserting the cannula portion of a pump and cannula system through the tricuspid valve, through the pulmonary valve and a sufficient length into the pulmonary artery to prevent collapse of the heart or pulmonary artery when the heart is stressed, lifted or displaced during surgery; and

pumping blood from upstream the pulmonary valve into the pulmonary artery to augment blood flow through the pulmonary valve produced by the beating heart.

34. A method according to claim 33 further comprising controlling the pump output in response to blood pressure, oxygen level, carbon dioxide level or flow level.

35. A method for performing heart surgery comprising:

providing a pump and cannula system comprising inflow and outflow cannulas and a pump communicating with the cannulas;

inserting the inflow cannula into a right side heart chamber;

inserting said outflow cannula through the pulmonic valve and into the pulmonary artery;

connecting said inflow cannula and said outflow cannula to said pump; and

controlling the pump to provide desired blood flow into the pulmonary artery during the surgery.

36. The method in claim 35 further comprising lifting or rotating the heart from its normal position.

37. A kit of parts for beating heart bypass surgery comprising:

a cannula system wherein the cannula is adapted for insertion through the tricuspid valve, through the pulmonary valve and a sufficient length into the

pulmonary artery to prevent collapse of the right atrium, right ventricle or pulmonary artery and to maintain partial blood flow there through while the beating heart is lifted or displaced during surgery and wherein the cannula is adapted for intake of blood upstream of the pulmonary valve and output of blood into the pulmonary artery while the beating heart is displaced during surgery; and

a pump adapted for communication with the cannula and for pumping blood through the cannula from upstream of the pulmonary valve to the pulmonary artery.

38. A kit of parts according to claim 37 wherein the cannula is a coaxial cannula wherein the outer cannula is the intake and the inner cannula is the output.

39. A kit of parts according to claim 37 further comprising:

a cannula system wherein the cannula is adapted for insertion through the bicuspid valve, through the aortic valve and a sufficient length into the aorta to prevent collapse of the left atrium, left ventricle or aorta and to maintain partial blood flow there through while the beating heart is lifted or displaced during surgery and wherein the cannula is adapted for intake of blood upstream of the aortic valve and output of blood into the aorta while the beating heart is displaced during surgery; and

a pump adapted for communication with the cannula and for pumping blood through the cannula from upstream of the aortic valve to the aorta.

40. A kit of parts according to claim 39 wherein the cannula is a coaxial cannula wherein the outer cannula is the intake and the inner cannula is the output.

41. A kit of parts according to claim 37 further comprising a controller adapted to control the pump in response to blood pressure, oxygen level, carbon dioxide level or flow level.

42. A kit of parts according to claim 39 further comprising a controller adapted to control the pump in response to blood pressure, oxygen level, carbon dioxide level or flow level.

43. A kit of parts for heart surgery comprising:

a cannula system wherein the cannula is adapted at one end for insertion through an incision in the vena cava or right atrium and adapted at the other end through an incision in the pulmonary artery to maintain blood flow there through while the heart is lifted or displaced during surgery and wherein the cannula is adapted for intake of blood from the vena cava or right atrium and output of blood into the pulmonary artery while the heart is displaced during surgery; and

a pump adapted for communication with the cannula and for pumping blood through the cannula from the vena cava or right atrium to the pulmonary artery.

44. A kit of parts according to claim 43 further comprising:

a cannula system wherein the cannula is adapted at one end for insertion through an incision in the pulmonary vein or the left atrium and adapted at the other end for insertion through an incision in the aorta to maintain blood flow there through while the heart is lifted or displaced during surgery and wherein the cannula is adapted for intake of blood from the pulmonary vein or left atrium and output of into the aorta while the heart is displaced during surgery; and

a pump adapted for communication with the cannula and for pumping blood through the cannula from the pulmonary vein or the left atrium to the aorta.

45. A kit of parts according to claim 43 further comprising a controller adapted to control the pump in response to blood pressure, oxygen level, carbon dioxide level or flow level.

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46. A kit of parts according to claim 44 further comprising a controller adapted to control the pump in response to blood pressure, oxygen level, carbon dioxide level or flow level.

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